Discriminant Analysis: Applications in Finance

Alka J. Bramhandkar, Finance, Ithaca College, Ithaca, New York

Abstract

This paper begins by defining and briefly explaining what discriminant analysis is. After noting the advantages and drawbacks of this statistical technique which is very similar to the regression analysis, the paper summarizes a number of important studies reported in the finance area during the last twenty years, using this technique. Some of the interesting efforts involve prediction of corporate bankruptcies, identification of conglomerate targets, prediction of bond rating, etc. The majority of the studies have relied on discriminant analysis to classify firms into two distinct groups. Few studies [e.g., studies on bond ratings] have used multiple discriminant analysis to identify more than two groups. Varying levels of accurate classification rates are reported depending on how the matched group was selected and which statistical procedures were used to select the independent, explanatory variables.

Introduction

Discriminant Analysis is computationally equivalent to regression analysis. It involves deriving linear combinations of two or more independent variables that will discriminate best between a priori defined groups, subject to the decision rule of maximizing the between-group variance, relative to within-group variance.

Discriminant Analysis has been used and applied in various disciplines such as marketing [to determine if statistically significant differences exist between two identifiable groups - buyer vs. non-buyer], psychology, sociology, international economics [to identify countries with development potential] etc., since the 1930's. In the following pages, many successful applications reported in the corporate finance area are discussed. A summary of fifteen such studies is provided in the attached table.

Although rigorous, this statistical technique has intuitive appeal because all of the relevant information is captured in one composite score after simultaneously analyzing the independent variables. In the finance field Altman (1) used it for the first time in 1968. Since then, over twenty-five studies have been reported on the use of discriminant analysis to identify the following groups: (1) Failed vs. Non-Failed firms, (2) In-

dustrial, municipal, bank holding companies' and electric utilities' bond ratings, and rating changes, (3) Acquired vs. Non-Acquired firms, and (4) Miscellaneous - companies with high vs. low price-earning ratio, etc.

Most of the studies have dealt with two mutually exclusive groups. Studies on bond ratings have used Multiple Discriminant Analysis to identify more than two groups. The majority of these have utilized linear discriminant analysis equation of the following form:

$$Z = W_1 X_1 + W_2 X_2 + \dots + W_n X_n$$

where:

Z = the discriminant score

W = the discriminant weights

X = the independent variables

The linear classification procedure of the above form is most appropriate if the variance of variables in both the groups is the same and covariance matrices are equal. Quadratic form has been used just in few studies.

The first topic, "Failed vs. Non-Failed" has received repeated attention for obvious reasons.

Failure of a company involves large economic costs. Lack of knowledge concerning the variables that are relevant for distinguishing between healthy and not so healthy firms can spell disaster for investors, auditors and corporate managers.

Altman (1), bridged the gap between traditional ratio analysis and discriminant analysis. Prediction of bankruptcy was used as an illustrative case. Deakin (8) improved Altman's results by carefully matching each failed firm with a non-failed firm on the basis of industry classification, year of financial information provided, and asset size. Various other studies using different matching procedure have also been done. Blum (6) incorporated changes in variables over time and Altman-Loris (2) focused on a special category of firms - NASD. A major modification to financial data to reflect capitalization of leases, contingency reserves, goodwill, deferred charges, etc., was done by Altman, Haldeman and Narayan (3). Both linear and quadratic discriminant analysis were used. However, no major improvement in the classification rates was reported due to data modification or quadratic specification of the equation. Sinkey (30) utilized a unique application of discriminant analysis in his study of Franklin National Bank - a large bankrupt bank. Since the number of Franklin-size failed banks is not large enough to permit two-group tests, outlier/peer group model was used. Norton and Smith (17) used ratios computed from statements adjusted for general price level changes. Results showed little difference between general price level adjusted and historical cost statements.

Pinches and Mingo (23) used this multivariate statistical tool for the first time to classify more than two groups. The joint application of factor analysis and multiple discriminant analysis was found to be viable in predicting bond ratings. Bond ratings can have significant consequences for both the borrowers and investors. Bond rating, which represents the judgement of the informed and sophisticated financial analysts concerning the credit risk of firms, affects cost of debt, cost of equity and marketability of the issue. It is therefore no surprise that this has been the subject of numerous studies in recent years. In 1979, Bhandari, Soldofsky and Boe (5) used discriminant analysis to identify rating changes rather than actual rating of utility bonds. Raman did a similar

study of municipal bonds in 1981, but also included non-fiscal variables to explain rating change.

Commercial paper, besides being a recent financial tool, is also quite distinct from bonds. It is relatively default free and is considered short term debt (average maturity three months). Rating agencies routinely assign credit rating to commercial paper. Peavy and Edgar (19) studied commercial paper issued by 83 bank holding companies. Five variable multiple discriminant analyses were able to achieve 88% accurate classification.

Distinguishing between acquired and non-acquired firms is the third important area in finance where multiple discriminant analysis has been successfully applied. Mergers and acquisitions have tremendous impact on the stock price of both the firms, creditors and employees. Knowledge regarding objective determinants of firms that merge improves understanding and helps the affected market participants plan on an appropriate strategy. Simkowitz and Monroe (28) used the discriminant analysis model to assign firms to acquired and non-acquired categories. Stevens (31) reported a different conclusion by stating that non-financial variables did not discriminate between firms that merge and firms that do not merge.

This simple statistical technique has also been used in miscellaneous areas such as classifying high/low P/E ratio firms, explaining commercial bank profitability, Haslem and Longbrake (12), separating adequately and inadequately capitalized firms, Dince and Forston (10). Martin and Scott (14) described profiles of a sample of debt equity issuing firms and utilized it to address the choice between new debt and equity.

Over twenty-five studies have been reported on the use of discriminant analysis as a predictive and analytical tool in the finance area. Topics covered by these studies are wide ranging. High, accurate classification rates have proven that this statistical technique is a tremendously valuable tool to the financial analysts, regulators, and investors. Due to its simplicity and its ability to uncover possible critical interrelations among the explanatory variables, we can expect wider use of this method in the near future.

Summary of Studies Reporting Application of
Discriminant Analysis in Finance

I. FAILED VS. NON-FAILED FIRMS

<u>Author</u>	<u>Sample, Technique Description</u>	<u>Conclusion</u>
Altman 1968	33 bankrupt manufacturers and 33 healthy firms with asset size in excess of \$1 mm. linear discriminant analysis using financial ratios such as working capital to total assets, retained earnings to total assets, EBIT and sales to total assets, etc.	95% classification rate using data one year prior to bankruptcy (72% - 2 years).
Deakin 1972	32 failed firms (1964-70) matched with non-failed firms based on industry classification, asset-size, etc.	97% classification rate one year prior to failure (96.5% - 2 years).
Blum 1974	Paired sample of 115 failed & non-failed firms. Used changes in variables over time.	94% one year 80% two years cash-flow to total debt most important ratio.
Altman & Loris 1976	Liquidated & healthy NASD firms. Quadratic & linear discriminant analysis.	90% accuracy using six financial variables.
Altman, Haldeman & Narayan 1977	53 bankrupt, 58 non-bankrupt firms (matched by industry, year of data with asset size exceeding \$20 million.) Financial data (7 variables) modified to reflect capitalization of leases, goodwill, etc.	90% accuracy.
Sinkey 1977	Compare one large failed bank to 50 large non-failed banks (1969-73). Two-group, outlier-peer group model.	Franklin - large failed bank presented significantly different financial profile.
Norton & Smith 1979	30 failed and non-failed firms matched by industry and asset size (1971-73). Financial statements adjusted for general price changes.	Results were not different from historical cost statements results.

II. BOND RATINGS

Pinches & Mingo 1973	180 industrial bonds rated B or above and listed in the new issue section of the Moody's bond survey (1-1-67 to 12-31-68).	69.7% accuracy.
	35 variable financial data screened by factor analysis to select six variables that can predict industrial bond ratings.	Model performed poorly for Baa rated bonds.
Pinches & Mingo 1975	Used above model and incorporated subordination as an explanatory variable.	91.5% accuracy.
Michel 1977	50 municipal bonds issued by large cities during 1962 - 1971.	59.6% accuracy.
	12 ratio selected due to the importance attributed to them by municipal authorities & previous studies.	Baa bonds misclassified frequently.
Raman 1981	30 cities that had their rating upgraded or downgraded matched with the control group.	86-90% accuracy 3 years prior to change based on fiscal variables.
		96-100% accuracy when non-fiscal variables such as geographic location were included.
		Rating agencies lagged the market.
		Operating working capital flow found to be most important variable.

III. ACQUIRED VS. NON-ACQUIRED

Simkowitz & Monroe 1968	1968 data	Smaller firms with low P/E ratios, lower dividend payout & lower growth in equity were most likely to be acquired.
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IV. MISCELLANEOUS

Walter 1959	50 large firms with high & low P/E ratios.	Financial variables such as dividend payout, stock price variability, etc. were able to classify firms into high or low P/E ratio category.
Martin & Scott 1974	62 industrial firms issuing only debt and 50 issuing only common stock during 1972.	78% of the sample was correctly classified based on financial ratios in the category of liquidity, leverage, dividend policy, etc. Certain ratios were calculated relative to industry norm.
Daigler & Fielitz 1977	Two sets of variables designated as regular (volume) and percentage were employed to see if daily technical indicators can correctly predict direction of change in Standard & Poor's 500 index.	65-80% of observations were correctly classified in bull and bear markets.

REFERENCES

- Altman, Edward I. (1968) "Financial Ratios, Discriminant Analysis and The Prediction of Corporate Bankruptcy", *Journal of Finance*, Vol. 23, No. 4, pp. 589-609.
- Altman, Edward I., and Beltina Loris. (1976) "A Financial Early Warning System for Over-The-Counter Broker-Dealers", *Journal of Finance*, Vol.31, No.4, pp. 1201-1217.
- Altman, Edward, I., Robert Haldeman, and P.G. Narayan (1977) "Zeta Analysis", *Journal of Banking and Finance*, Vol.1, pp. 29-54.
- Belkaoui, Ahmed (1980) "Industrial Bond Ratings: A New Look", *Financial Management*, Vol.9, No.3, pp. 44-51.
- Bhandari, Shyam B., Robert M. Soldofsky, and Warren J. Boe (1979) "Bond Quality Rating Changes for Electric Utilities: A Multivariate Analysis" *Financial Management*, Vol.8, No.1, pp. 74-81.
- Blum, Mark. (1974) "Failing Company Discriminant Analysis" *Journal of Accounting Research*, Vol.12, pp. 1-25.
- Daigler, Robert T., and Bruce D. Fielitz (1977) "A Multiple Discriminant Analysis of Technical Indicators of the NYSE" *Journal of Financial and Quantitative Analysis*, Vol.12, No.4, pp. 677-8.
- Deakin, Edward B. (1972) "A Discriminant Analysis of Predictors of Business Failure" *Journal of Accounting Research*, Vol.10, No.1, pp. 167-179.
- Dhrymes, P. *Econometrics*, New York: Springer-Verlag, 1974. Corrected reprint of 1970 edition published by Harper & Row, New York.
- Dince, Robert R., and James C. Forston (1972) "The Use of Discriminant Analysis to Predict the Capital Adequacy of Commercial Banks" *Journal of Bank Research*, pp. 54-62.
- Giroux, Gary, and Nicholas G. Apostolou (1987) "New Bond Rating Classification Accuracy" *Review of Business and Economic Research*, Vol.22, No.2, pp. 68-76.
- Haslem, John A., and William A. Longbrake (1971) "A Discriminant Analysis of Commercial Bank Profitability" *The Quarterly Review of Economics and Business*, Vol.11, No.3, pp. 39-46.
- Klemkosky, Robert C., and J. William Petty (1973) "A Multivariate Analysis of Stock Price Variability" *Journal of Business Research*, Vol.1, pp. 1-10.
- Martin, John D., and David F. Scott, Jr. (1974) "A Discriminant Analysis of Debt-Equity Decision" *Financial Management*, pp. 71-79.

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